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PICEA

(spruces)

The spruces (*Picea*) total 35 to 40 species, about half confined to China, where the exact number of intergrading species is uncertain. They are widely distributed in coniferous forests of cooler north temperate regions. They extend southward to high mountains in northern Mexico, southern Europe, Asia Minor, Himalayas, and Taiwan. Of the 7 species native in the United States, 5 are of interest in silviculture.

Thin scaly bark is characteristic. Buds are usually not resinous. The needlelike leaves, persistent up to 10 years, are borne on peglike stalks which remain on older twigs. The needles are 4-angled or in a few species flattened, stiff, and sharp-pointed.

In spring a tree bears male and ovulate strobili, the former from buds along the twig growth of the previous year and the latter terminal. The egg-shaped or cylindric cones, mostly in the upper part of the crown, mature in one season, hang down, and remain attached for some time. The many cone scales bear at the base 2 long-winged seeds. Cotyledons 4 to 15.

F-490500

SITKA SPRUCE (*Picea sitchensis* (Bong.) Carr.)

Other common names: Coast spruce, tideland spruce, yellow spruce.

Sitka spruce, the largest of the spruces, grows in a narrow strip along the Pacific coast from northwestern California to southern Alaska. The range, over 1,800 miles long, is closely associated with the fog belt, varying in width from a few miles in California to about 130 miles in Alaska. In California the range is restricted to the mouths of streams and low valleys facing the ocean. Maximum width in Oregon and Washington is about 30 miles.

Sitka spruce reaches maximum development on the Olympic Peninsula of Washington and the Queen Charlotte Islands of British Columbia. Here the rain forests of Sitka spruce and western hemlock grow under what may be the best forest growth conditions found on the North American Continent.

HABITAT CONDITIONS

Climate

Sitka spruce forests grow in a superhumid climate (*29*)[1], greatly influenced by the prevailing westerly winds from the Pacific Ocean. Weather it characterized by equable temperatures, high precipitation, cloudiness averaging 200 days per year, and an absence of extreme winter cold (*14*) (table 1). The amount of summer precipitation increases northward in the spruce belt. In spite of the long north to south distribution of this species, climatic variations are not great because of the equable ocean current of the north Pacific. The shorter growing season in the north is partly offset by long summer days. Precipitation on the west slopes of coastal mountains increases rapidly with elevation and a greater percentage falls as snow. Along the south coast of Alaska winter precipitation near tidewater is mostly rain; above 600 feet elevation, however, snowfall is common and the snow pack reaches great depths (*13*).

[1] Italic numbers in parentheses refer to Literature Cited, p. 316.

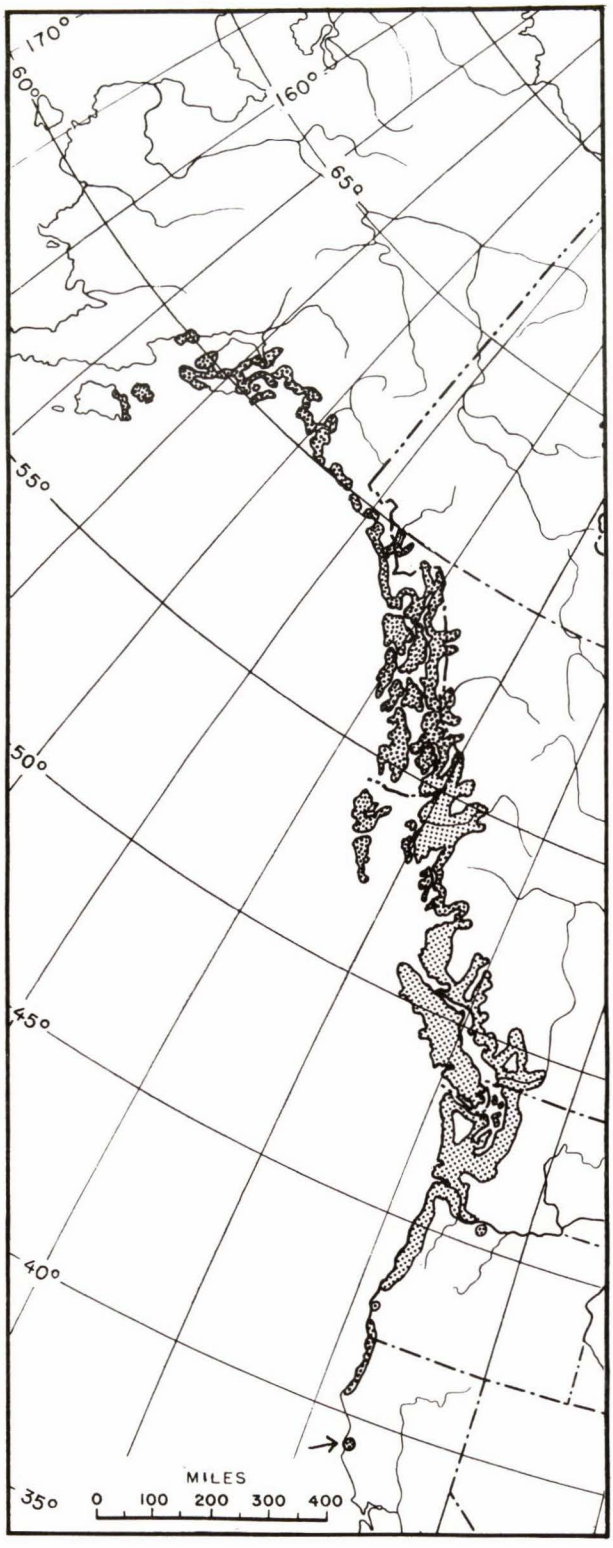
Soils and Topography

Since the species is restricted to a narrow strip along the coast, the soils are fairly similar in development. They are usually high in organic matter, containing as much as 20 percent in surface horizons. Many areas, particularly in Alaska, have thick accumulations of raw humus or moss. In the north, Sitka spruce is often found on coarse-textured, thin soils and on wet rocky slopes facing

TABLE 1.—*Climate in the range of Sitka spruce*[1]

Location	Elevation	Average precipitation		Temperature					Average annual frost-free period
				Average			Absolute		
		April–September	Annual	Annual	January	July	Maximum	Minimum	
Alaska:	*Feet*	*Inches*	*Inches*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	*Days*
Seward	76	28.4	73.7	39.5	22.4	55.3	82	−20	132
Cordova	40	65.5	145.4	38.6	27.2	54.8	87	−19	149
Sitka	15	34.7	87.1	45.6	32.4	54.9	87	−5	159
Wrangell	37	31.0	83.0	43.9	29.0	58.2	92	−6	169
Ketchikan	0	57.5	150.9	46.4	32.6	57.5	96	−8	165
British Columbia:									
Masset	30	20.8	53.9	45.6	35.8	58.1	84	−2	169
Vancouver	136	15.9	58.7	49.0	35.6	63.3	92	2	219
Washington:									
Quinault	220	29.9	128.6	50.9	38.4	63.5	104	11	208
Aberdeen	135	18.7	82.9	49.9	39.2	59.6	105	6	191
Oregon:									
Astoria	220	17.0	77.5	51.2	40.3	60.9	97	10	273
Newport	155	15.0	66.2	50.9	43.7	56.8	100	1	248

[1] Compiled from U.S. Weather Bureau records and from weather records of the Department of Agriculture, British Columbia.



F–506615

The range of Sitka spruce.

the sea, where it does not grow well unless the rock structure is fractured. On thin soils western redcedar and Alaska cedar often make up a large part of the forest stand. In the south Sitka spruce is usually restricted to alluvial soils or sandy bottoms along streams. In Alaska drainage is a critical factor and growth is poor on swampy sites except where ground water is moving. Spruce follows lodgepole pine on coastal sand dunes as they become stabilized by lesser vegetation, and on peat bogs as they mature. In many areas Sitka spruce eventually gives way to hemlock as more humus is formed (*12*). Some of the better soils for Sitka spruce in Oregon and Washington include the Astoria and Olympic series. Values of pH of 4.0 to 5.7 are typical of soils supporting spruce stands.

In the north and west parts of its range in Alaska, commercial stands of Sitka spruce extend from tidewater up to about 1,000 feet elevation. Southward it grows at higher elevations, reaching 2,000 to 3,000 feet in southeastern Alaska. In southeastern Alaska, the mountains rise so abruptly from the shore that a strip of timber extending to 3,000 feet in elevation is usually all within sight of tidewater. In fact, timbered areas are seldom found more than 5 to 6 miles inland and three-fourths of the commercial stands are estimated to be within 2½ miles of tidewater (*13*).

In British Columbia, Sitka spruce is seldom found at elevations exceeding 1,000 feet; the highest on record is 2,500 feet. Southward through southwest Washington and western Oregon to northern California, the spruce belt gradually narrows. The upper elevational limits also gradually decrease until in northern California merchantable trees can only be found in narrow strips along coastal streams.

Associated Trees and Shrubs

Sitka spruce is a major species in two forest types: Type 223, Sitka Spruce, and Type 225, Sitka Spruce—Western Hemlock. It is a minor component of nine other forest types.

Type No.	*Type*
202	White Spruce—Birch
206	Engelmann Spruce—Subalpine Fir
221	Red Alder
224	Western Hemlock
227	Western Redcedar—Western Hemlock
228	Western Redcedar
229	Pacific Douglas-Fir
230	Douglas-Fir—Western Hemlock
231	Port-Orford-Cedar—Douglas-Fir

The most common associate of Sitka spruce is western hemlock. In addition to the species noted in the types above, Sitka spruce grows with lodgepole pine on sand dunes and peat bogs along the coast; with Pacific silver fir in Oregon, Washington, and British Columbia; mountain hemlock in

Alaska; and redwood in northern California. Other associated trees of little commercial value include vine maple (*Acer circinatum*) and willow (*Salix* spp.). Several shrubs that are typical of Sitka spruce stands are very important competitors during seedling establishment and early growth. These include salmonberry (*Rubus spectabilis*), thimbleberry (*R. parviflorus*), several huckleberries (*Vaccinium* spp.), Pacific red elder (*Sambucus callicarpa*), rusty menziesia (*Menziesia ferruginea*), devilsclub (*Oplopanax horridus*), and salal (*Gaultheria shallon*).

LIFE HISTORY

Reproduction and Early Growth

Flowering and fruiting.—In the central and southern part of the range, flowering occurs in late March and April. Male buds, produced in large numbers near the ends of lateral branchlets, develop into conspicuous rose-red pollen-bearing strobili from ¾ to 1½ inches long and about ½ inch in diameter. Female flower buds are borne on the ends of the primary branches and develop into erect, yellowish-green conelets, often tinged with red, about 1 inch long and ½ inch thick when receptive. Pollen shedding begins the last week in April along the central Oregon coast and ends the latter part of May. After pollination the small cones turn down, slowly lose their red appearance, except sometimes on the side near the sun, and develop into mature pale yellow to reddish-brown cones 2½ to 4 inches long. Cones begin to open in late September.

In southeast Alaska seed development is completed in less time. Pollen shedding begins from mid- to late May. Seeds ripen about mid-September.

Seed production and dissemination.—Sitka spruce is generally considered a prolific seed producer; a good crop of cones is produced every 3 to 4 years with light crops intervening. Seed crop failures do occur but are uncommon. Seed production begins in 20- to 40-year-old stands with a few cones in the upper crown. In Alaska seed production is poorer, with a greater interval between seed crops and with seed crop failures more common.

On the central Oregon coast in 1949–52 seed fall began the last 10 days in October and was apparently triggered by the first dry easterly winds that occur during this period (*24*). The first day's fall is usually very heavy and dissemination during short dry periods is from east to west. When drying winds fail to occur, only a few seeds fall during October; the main crop falls later and is disseminated from southwest to northeast. Fifty percent of the viable seed crop is normally on the ground by mid-November and 90 percent by about February 1, but some seed falls as late as April and May. In Alaska seed fall may begin in late September, but the greatest dissemination takes place during dry periods in mid-October (*8*).

The central Oregon coast study showed that seed fall under dense timber is 15 times greater than on small clear-cut tracts and that spruce is not as prolific a seed producer as its most common associate, western hemlock. In Alaska adequate seed dispersal has been recorded up to ¼ mile from the seed source and seeds sometimes blow along the surface of the snow up to ½ mile or more (*16*). Scrubby spruce stands will produce about the same quantities of seed as well-formed, vigorous stands (*15*).

Sitka spruce seed is small, with 210,000 cleaned seed per pound. Average rate of fall in still air has been calculated to be 3.1 feet per second (*26*).

Several insects are known to destroy the developing cones and seed. One, a seed chalcid (*Megastigmus piceae*), feeds on and destroys Sitka spruce seeds in Oregon and California, occasionally destroying a large part of the seed crop. It has also been found in spruce cones in Alaska, along with another chalcid (*Torymus* spp.) and a fly (*3*). Two species of cone moths have been identified in spruce cones, *Laspeyresia youngana* and *Heinrichia fuscodorsana* (*3*). Finally, chipmunks and squirrels clip the cones and consume seed on the ground. But at this stage mice and shrews account for most of the loss.

Seedling development.—Sitka spruce seed will germinate on almost any kind of seedbed if moisture is abundant. Establishment is best on mineral soil with side shade and overhead light, but seedlings also establish on organic seedbeds such as rotten wood, or moss. In Alaska, however, moss and organic layers become very thick and form a seedbed in which moisture fluctuates greatly. Heavy seedling mortality occurs during dry spells even when they are of short duration (*9*). On most organic seedbeds western hemlock germinates and survives better than Sitka spruce. Spruce has an advantage over hemlock, however, on bare soil and the percentage of spruce reproduction often can be increased by clear cutting and exposing more mineral soil during the logging operation (*2, 10, 23*).

In Alaska, low temperatures during the growing season are apparently a limiting factor and seedling survival and growth are better on south than on north slopes. Farther south, moisture becomes a limiting factor. The downward growth of roots of spruce seedlings on south slopes cannot keep pace with the desiccation of the soil during dry periods. At the end of the first growing season the initial root system consists only of a few lateral roots 4 inches or more long and spread out 1 to 3 inches under the soil surface.

In such a situation seedling survival is better on north slopes.

Shrubby competition, such as from salmonberry, thimbleberry, and alder, seriously retards seedling growth, particularly on moist, exposed sites. Here the shrubs easily outgrow the spruce seedlings. Frequently, only those seedlings survive which are growing on rotten wood, where shrub growth is inhibited.

Sitka spruce is more resistant to herbicides, in the concentrations and formulations used to control alder and brush, than either Douglas-fir or western hemlock (*19*).

Deer browsing sometimes retards seedling establishment. However, deer prefer hemlock, Douglas-fir, and the cedars to Sitka spruce, and browsing of spruce seedlings has not been a serious problem.

Sitka spruce bud bursting begins in mid-April in Oregon, late April in Washington, and usually in May in British Columbia and Alaska. In Alaska most leader growth occurs in June; it usually terminates before that of western hemlock (*7*, *11*).

Vegetative reproduction.—Vegetative reproduction is uncommon. Sitka spruce does not sprout from stump or root, but layering has been known to occur, although it is not used in management of the species. Spruce cuttings have been successfully rooted in the greenhouse (*4*, *6*, *20*).

F–70502

An old-growth Sitka spruce in Alaska, showing buttressed and swollen base.

Sapling Stage to Maturity

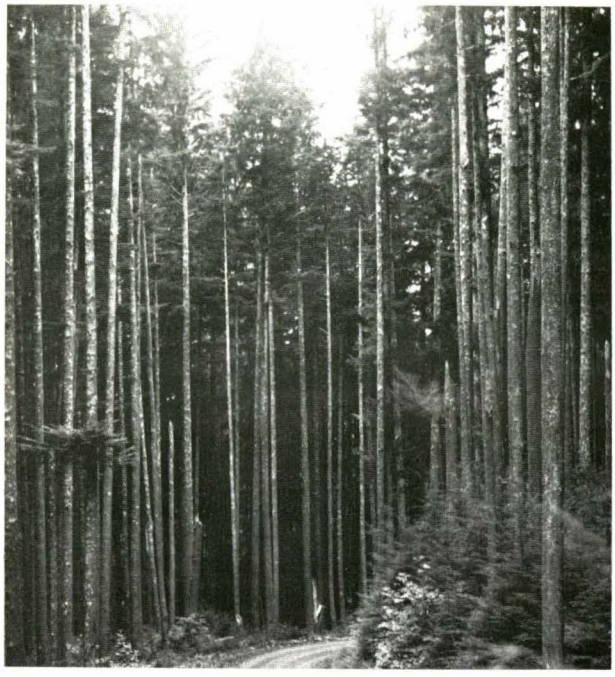
Growth and yield.—Sitka spruce is a vigorous, fast-growing tree that readily overtops associated western hemlock and cedars to occupy the dominant position in the stand. Mature trees are often very impressive, with swollen and buttressed bases, straight, slightly tapering boles as high as 285 feet.

The forest of maximum volume and value is probably a well stocked spruce-hemlock stand with the larger and taller spruce occupying the dominant position in the canopy interspersed with codominant and intermediate hemlock. Spruce seldom survives as an understory to hemlock, but hemlock does very well as an understory to spruce (*27*). One yield plot in a 147-year-old stand in coastal Oregon contained, on an acre basis, 76 spruce trees averaging 34.3 inches in diameter and 210 feet in total height and 13 hemlocks averaging 18.1 inches in diameter and 144 feet in height. Total volume per acre was 34,003 cubic feet or 261,284 board feet (International). Based on the Sitka spruce in the stand, site index was 174. On the best sites mean annual gross growth of well-stocked spruce stands is about 2,000 board feet (International) per acre at a rotation age of 80 to 90 years.

In Alaska average diameter of mature trees is 5 feet, with a maximum of 8 feet or more. In British Columbia, Washington, and Oregon, trees up to 10 feet or more in diameter are found. The largest tree measured was 16.4 feet and the tallest tree, 286 feet (*1*).

Sitka spruce is generally considered shallow-rooted and susceptible to windthrow. In climax forests of southeastern Alaska root penetration of spruce and hemlock into mineral soil averaged 6.5 inches in areas with good drainage. In poorly drained areas roots stopped in the thick organic horizons 10 inches above mineral soil (*10*). However, Sitka spruce roots have been found at depths greater than 6 feet deep in well-drained alluvial soils on the Queen Charlotte Islands of British Columbia (*5*).

Reaction to competition.—Sitka spruce is classed as tolerant, placing it in the second of five tolerance classes. Its most common associate, western hemlock, is classed as very tolerant, the most tolerant of western conifers. Western redcedar is also more tolerant than spruce, but spruce is considerably more tolerant than Douglas-fir. Pure spruce stands are essentially a subclimax type eventually being replaced by the spruce—hemlock or hemlock—western redcedar climax. The spruce—hemlock mixture is considered essentially a climax type but with the qualification that hemlock is the more stable of the two species. Mixed



F–472994

A dense young-growth stand of Sitka spruce and hemlock on the Cascade Experimental Forest, Oreg.

stands of spruce—hemlock may originate as an even-aged stand following fire or other catastrophe, or they may result when hemlock originates as an understory in a spruce stand and eventually replaces part of the spruce overstory. As even-aged spruce—hemlock reaches maturity, the hemlock dies out first since few trees live more than 500 years. Sitka spruce, in contrast, may live to an age of 700 or 800 years, and often remains as a scattered overstory. Since new reproduction under the stand is predominantly western hemlock, this more tolerant species eventually dominates the site when the veteran spruces die.

Along the Oregon and Washington coasts Sitka spruce slowly replaces the less tolerant lodgepole pine which is a pioneer tree species along the beach. A short distance inland Sitka spruce may start as a pure stand but is usually invaded rapidly by western hemlock, particularly on the better soils. Farther inland where moisture becomes limiting, Sitka spruce is replaced by Douglas-fir. In British Columbia the spruce stands of the coast often merge with the western redcedar—western hemlock climax as they move inland. Farther from the coast and on higher and drier sites, Douglas-fir, Pacific silver fir, and grand fir slowly replace spruce in the stand.

In southeastern Alaska, the climax forests contain about 74 percent hemlock by volume compared to 20 percent spruce. Since spruce grows best on exposed mineral soil, it will be favored by clear cutting, and second-growth stands are expected to contain about 50 percent spruce (*28*). Sitka spruce that has been suppressed by alder or an overstory of other conifers responds well to release and grows vigorously.

Sitka spruce is one of the few conifers that develops epicormic branches along the bole. Some branching is present even in dense stands and it increases materially when light is increased by removal of nearby trees. Spruce along road rights-of-way develop a solid mass of new foliage from the base of the tree up to the crown. Any thinning designed to accelerate growth of clear wood on crop trees must be done with caution. In a dense stand large limbs in the lower crown die and break off relatively early in the rotation. The branch stubs, however, are very resinous and remain on the stem for many years, delaying the production of clear lumber.

Principal enemies.—Blowdown is a major hazard but spruce is more windfirm than hemlock. Ninety-three percent of the blowdown on the borders of clear-cut areas was concentrated along north and east boundaries. Losses were much heavier when these boundaries were located on the leeward side of ridges, that is, on north slopes. Most loss occurs in the north and east cutting boundaries (*25*).

Sitka spruce is very susceptible to decay following injury. In partially cut stands in western Washington and Oregon, 58 percent of the scars were infected. Brown crumbly rot (*Fomes pinicola*) was most destructive and most common but 10 other rot fungi were identified. Penetration of decay was related to size and age of scar (*30*). Studies in Alaska showed that decay, increasing with age of the tree, amounted to 25 percent of the volume of 500-year-old trees (*17*, *18*).

Spruce is also attacked by several species of insects that kill or damage large volumes of timber when their populations reach epidemic stages. The Sitka spruce weevil (*Pissodes sitchensis*) kills terminal shoots of spruce. Trees 2 to 8 inches in diameter and 5 to 25 feet tall are most susceptible. The spruce aphid (*Aphis abientina*) has killed millions of feet of spruce in Oregon and Washington, particularly along the tidelands. The black-headed budworm (*Acleris variana*) has caused major defoliation in southeastern Alaska (*22*). The Sitka spruce beetle (*Dendroctonus obesus*) is considered a secondary enemy but at times kills a considerable amount of timber.

RACES AND HYBRIDS

No geographic races of Sitka spruce have been described. There is some range overlap with white spruce in Alaska and a natural hybrid (*Picea*×*lutzii* Little) occurs in that area (*21*).

733–741 O—65——21

Hybrids between Sitka spruce and Engelmann spruce occur in Denmark, and crosses with Norway spruce and Serbian spruce have been reported (*31*).

Revised from "Silvical Characteristics of Sitka Spruce," by Robert H. Ruth. U.S. Forest Serv. Pacific Northwest Forest and Range Expt. Sta. Silvical Ser. 8. October 1958.

LITERATURE CITED

(1) American Forestry Association.
1956. These are the champs. Part 2. Amer. Forests 62 (4) : 33–40.

(2) Andersen, H. E.
1955. Clear-cutting as a silvicultural system in converting old forests to new in southeast Alaska. Proc. Soc. Amer. Foresters 1955 : 59–61.

(3) Cambridge, W. F.
1957. A record of spruce cone insects in Alaska. U.S. Forest Serv. Alaska Forest Res. Center Tech. Note 34, 1 p.

(4) Cooper, William S.
1931. The layering habit in Sitka spruce and the two western hemlocks. Bot. Gaz. 91 : 441–451.

(5) Day, W. R.
1957. Sitka spruce in British Columbia. [London] Forestry Comn. Bul. 28, 110 pp.

(6) Doran, William L.
1957. Propagation of woody plants by cuttings. Mass. Univ. College Agr. Expt. Sta. Bul. 491, 99 pp.

(7) Godman, R. M.
1953. Seasonal distribution of leader growth. U.S. Forest Serv. Alaska Forest Res. Center Tech. Note 19, 1 p.

(8) ———
1953. Seed dispersal in southeast Alaska. U.S. Forest Serv. Alaska Forest Res. Center Tech. Note 16, 1 p.

(9) ———
1953. Moss retards regeneration in southeast Alaska. U.S. Forest Serv. Alaska Forest Res. Center Tech. Note 18, 1 p.

(10) ——— and Gregory, R. A.
1953. Physical soil characteristics related to site quality in climax stands of southeast Alaska. U.S. Forest Serv. Alaska Forest Res. Center Tech. Note 17, 1 p.

(11) Gregory, R. A.
1957. A comparison between leader growth of western conifers in Alaska and Vancouver Island. U.S. Forest Serv. Alaska Forest Res. Center Tech. Note 36, 1 p.

(12) Hansen, Henry P.
1947. Postglacial forest succession, climate and chronology in the Pacific Northwest. Amer. Phil. Soc. Trans., New Ser., v. 37. Part 1, 130 pp.

(13) Heintzleman, B. Frank.
1949. Forests of Alaska. U.S. Dept. Agr. Yearbook : 361–372.

(14) Heusser, Calvin J.
1961. Late-pleistocene environments of North Pacific America. Amer. Geog. Soc., 308 pp. New York.

(15) James, G. A.
1959. Seed production in a scrub stand. U.S. Forest Serv. Alaska Forest Res. Center Tech. Note 43, 3 pp.

(16) ——— and Gregory, R. A.
1959. Natural stocking of a mile-square clearcutting in southeast Alaska. U.S. Forest Serv. Alaska Forest Res. Center. Sta. Paper 12, 9 pp.

(17) Kimmey, James W.
1956. Cull factors for Sitka spruce, western hemlock and western redcedar in southeast Alaska. U.S. Forest Serv. Alaska Forest Res. Center. Sta. Paper 6, 31 pp.

(18) Klein, J. A.
1951. Defect in the climax forests of southeast Alaska. U.S. Forest Serv. Alaska Forest Res. Center Tech. Note 9, 1 p.

(19) Krygier, J. T., and Ruth, Robert H.
1961. Effect of herbicides on salmon berry and on Sitka spruce and western hemlock seedlings. Weeds 9 (3) : 416–422.

(20) Larsen, C. Muhle.
1955. The seasonal variation in the natural rooting capacity of cuttings of Norway spruce (Picea abies) and Sitka spruce (P. sitchensis). Ztschr. f. Forstgenetik u. Forstpflanzenzuchtung 4 : 69–80.

(21) Little, Elbert L., Jr.
1953. A natural hybrid species in Alaska. Jour. Forestry 41 : 745–746.

(22) McCambridge, W. F.
1955. Effects of black-headed budworm feeding on second-growth western hemlock and Sitka spruce. Proc. Soc. Amer. Forester 1955 : 171–172.

(23) Meyer, Walter H.
1937. Yield of even-aged stands of Sitka spruce and western hemlock. U.S. Dept. Agr. Tech. Bul. 544, 86 pp.

(24) Ruth, Robert H., and Berntsen, Carl M.
1955. A 4-year record of Sitka spruce and western hemlock seed fall on the Cascade Head Experimental Forest. U.S. Forest Serv. Pacific Northwest Forest and Range Expt. Sta. Res. Paper 12, 13 pp.

(25) ——— and Yoder, Ray A.
1953. Reducing wind damage in the forests of the Oregon Coast Range. U.S. Forest Serv. Pacific Northwest Forest and Range Expt. Sta. Res. Paper 7, 30 pp.

(26) Siggins, Howard W.
1933. Distribution and rate of fall of conifer seeds. Jour. Agr. Res. 47: 119–128.

(27) Taylor, R. F.
1929. The role of Sitka spruce in the development of second-growth in southeastern Alaska. Jour. Forestry 27: 532–534.

(28) ———
1934. Yield of second-growth western hemlock—Sitka spruce stands in southeastern Alaska. U.S. Dept. Agr. Tech. Bul. 412, 30 pp.

(29) Thornwaite, C. W.
1941. Atlas of climatic types in United States. 1900–1939. U.S. Dept. Agr. Misc. Pub. 421, 7 pp.

(30) Wright, Ernest, and Isaac, Leo A.
1956. Decay following logging injury to western hemlock, Sitka spruce, and true firs. U.S. Dept. Agr. Tech. Bul. 1148, 34 pp.

(31) Wright, Jonathan W.
1955. Species crossability in spruce in relation to distribution and taxonomy. Forest Sci. 1: 319–349.